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ENFOR Forecasting and Optimization for the Energy Sector

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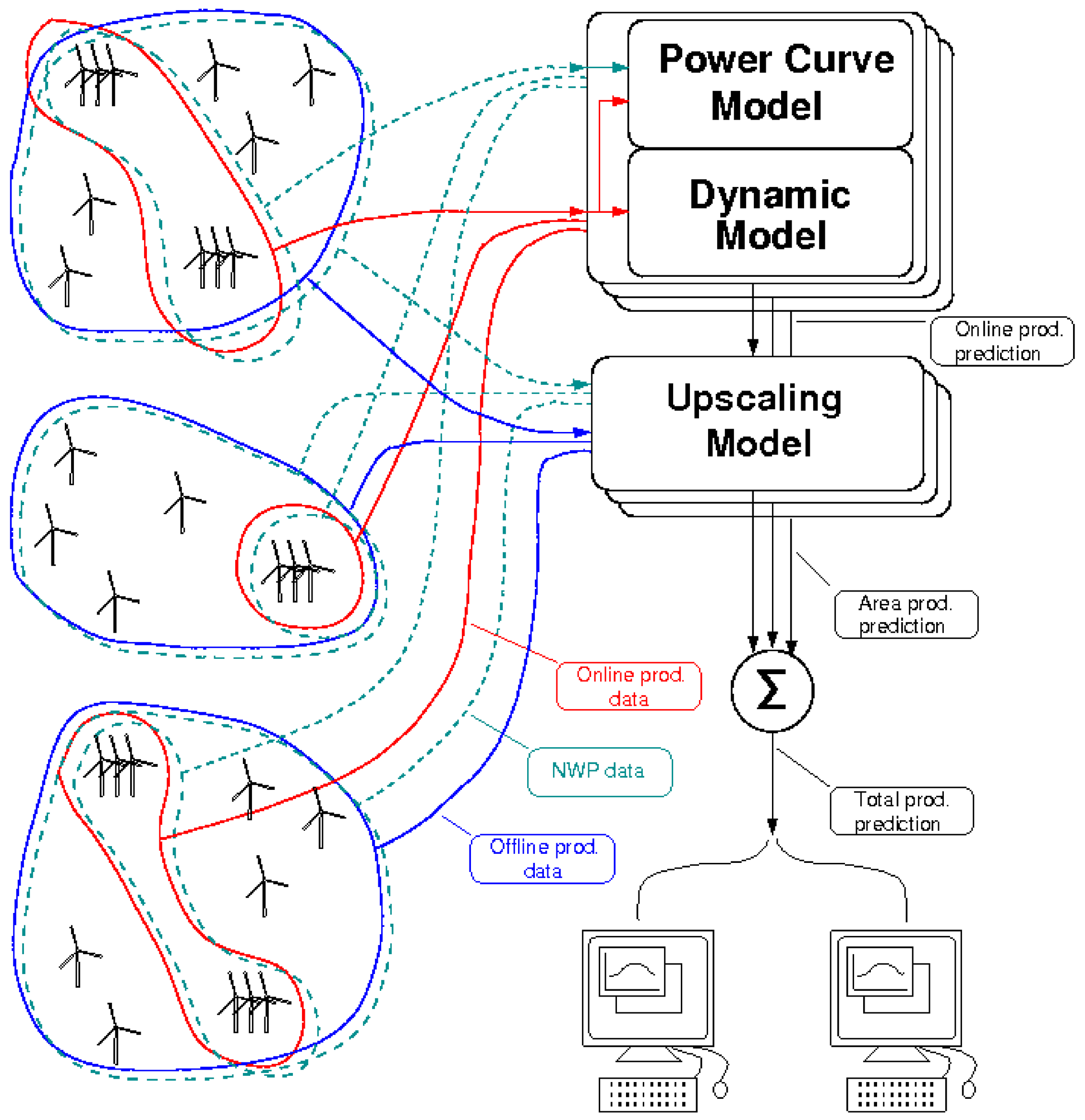
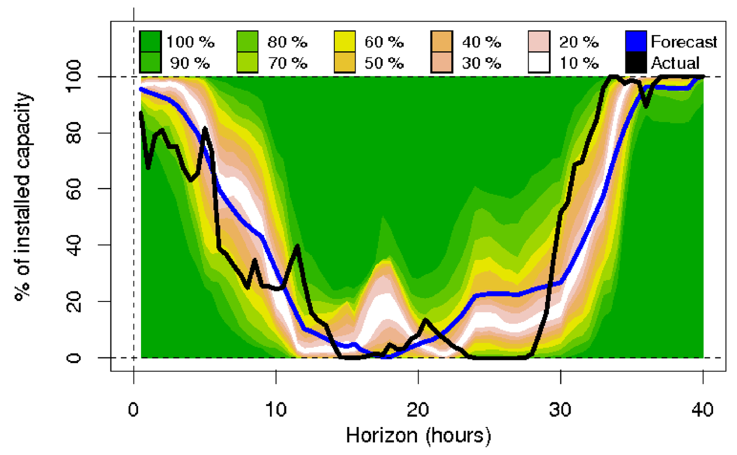
Abstract

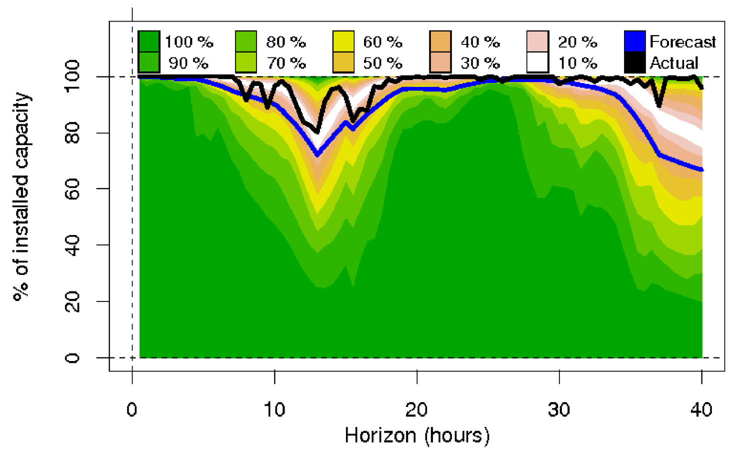
This poster describes the status as of April 2012 of the Public Service Obligation (PSO) funded project PSO 10464 "Integrated Wind Power Planning Tool". The project goal is to integrate a meso scale numerical weather prediction (NWP) model with a statistical tool in order to better predict short term power variation from offshore wind farms, as well as to conduct forecast error assessment studies in preparation for later implementation of such a feature in an existing simulation model. The addition of a forecast error estimation feature will further increase the value of this tool, as it's output can be fed into any type of system model or decision-making problem that wish to account for forecast errors in the planning process, rather than assume perfect forecasts.

Short term wind power forecasting



WRF output wind fields will be coupled to a widely used wind power prediction model, namely the *Wind Power Prediction Tool* (WPPT), maintained by ENFOR A/S; a Danish company that specialises in forecasting and optimisation for the energy sector. This integrated wind power prediction tool will produce scenario forecasts for the coming hours to days, which can then be fed into any type of system model or decision making problem to be solved. Examples of WPPT scenario forecasts are shown below.

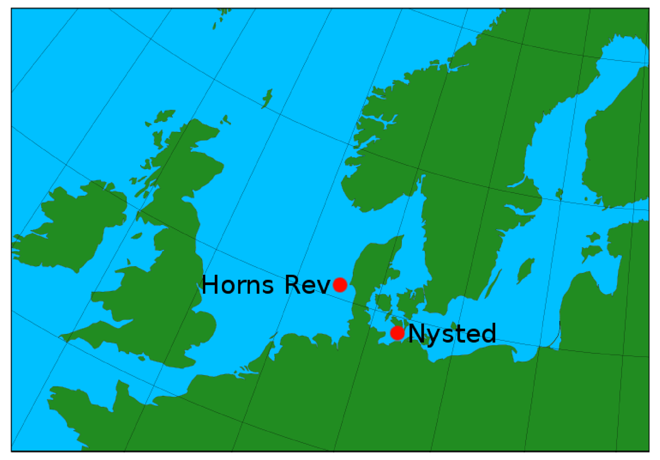




Wind field modeling with a meso scale numerical weather prediction tool

For any energy system relying on wind power, accurate forecasts of wind fluctuations are essential for efficient operation. The further the transmission system operator (TSO) can plan ahead, the greater the savings: Wind energy is better utilised if accurate predictions are available to the TSO and wind farm owners.

Currently, most wind power fluctuation models are either purely statistical or integrated with NWP models of limited resolution. This project addresses the latter issue by using the meso scale *Weather Research & Forecasting* (WRF) NWP model to generate the required input wind fields for the short term prediction tool. Several regions of interest are in play, though the main focus will be on the Horns Rev 2 and



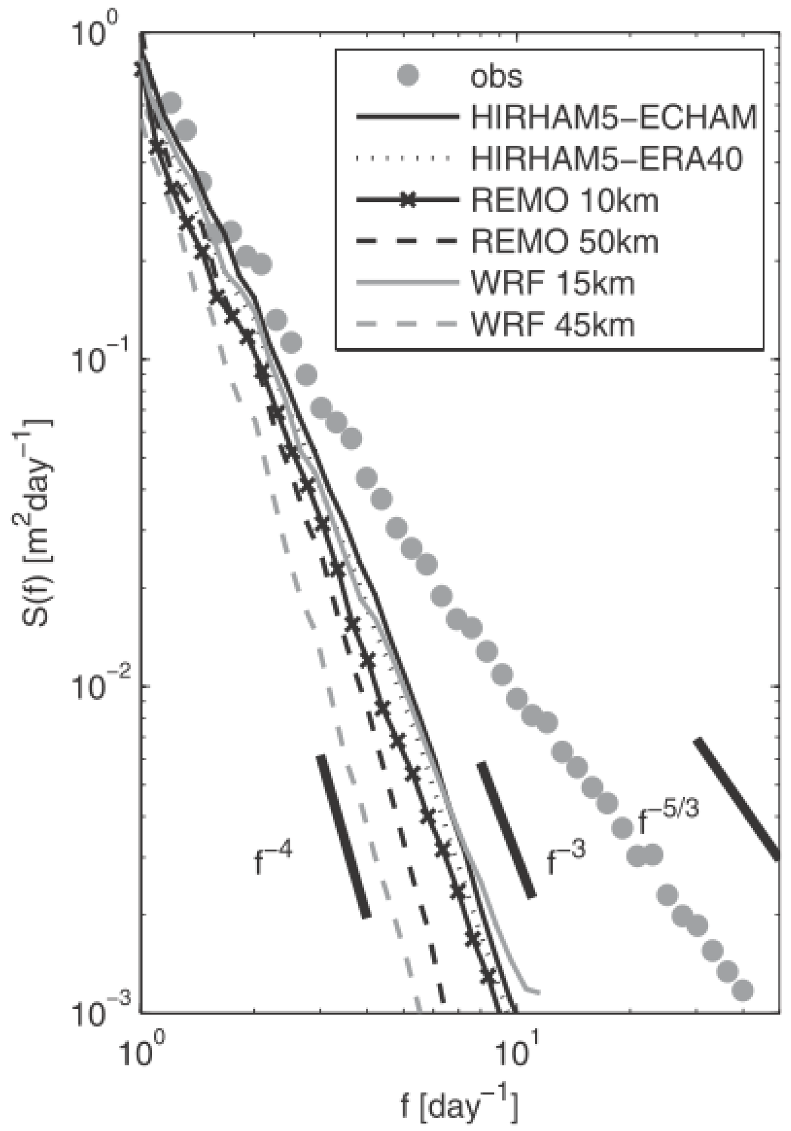
Nysted wind farms in western and southern Denmark, respectively. A sketch of the planned WRF domain is shown to the left. Basis for the investigations will be weather forecasts from the National Centers for Environmental Prediction (NCEP, USA) *Global Forecast System* (GFS) model. A comparison study of wind forecasts [4] will be carried out in order to quantify the gain from increasing the resolution.

Wind forecast error characterisation

A simulation tool, *CorWind 7*, has been developed at the DTU Wind Energy department [6], providing wind power time series intended for long term power system planning. At present, CorWind 7 is used to simulate power fluctuations in offshore wind power for Northern Europe 2020 and 2030 scenarios, as part of the TWENTIES project.

The model takes input from WRF simulations that – as all NWP models – underestimate the high-frequency variability of the wind; see the figure to the right [2].

As part of the ongoing development effort, preparatory WRF studies will be carried out for a future implementation of forecast error assessment in the CorWind simulation tool: The aim is to characterise dynamically the forecast errors in large areas.



Expected outcome from PSO 10464

The two major aims with PSO 10464 is to develop an integrated wind power forecasting model, that allows for the description of the expected variability in wind power production in the coming hours to days, as well as to dynamically characterise the wind forecast error in large regions.

Using high resolution WRF results in the integrated short term prediction model will ensure a high accuracy data basis for use in the decision making process of the Danish TSO and energy authority. The need for correct wind power predictions will only increase over the next decade as Denmark approaches the new goal of 50% wind power based electricity in 2020. In that respect, adding forecast error characterisation features to a simulation tool that can be used for assessing variability in the power contribution from future wind farms constitute valuable input to the planning process for these.

NWP and scenario forecast validation

Before the WRF results can be used for further studies, these must be compared to actual wind measurements in the domain of interest, including:

- Conventional meteorological stations across Denmark, Sweden and Northern Germany;
- satellite-derived winds over ocean regions surrounding Denmark;
- mast wind measurements at Horns Rev and Nysted.

As part of this project, the high-frequency variability of the wind field will be validated using the mast wind observations. This range of periods includes events such as convective rainfall and post-frontal instability and sudden changes to the wind field due to intense storms and frontal passages. The validation procedure will be carried out using techniques employed in recent literature [9, 5, 8].

Output from the integrated short term prediction tool will be verified using state-of-the-art probabilistic forecast verification approaches [3, 1], and also using some new concepts that are appearing in the literature (e.g. the spectral verification works performed at the DTU Wind Energy department [7]). The basis for validation is power data from the Danish TSO, Energinet.dk, which is expected to be minutes resolution of data at transmission system station level.

For both the integrated short term prediction tool and forecast error characterisation tasks, the extend to which additional wind variability is captured when increasing the meso scale model resolution is sought quantified. To this end, it is important to determine whether the modeled wind fluctuations agree with observations in terms of power spectral densities, as well as whether the occurences of high-frequency wind fluctuations match those of historical records.

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